

# NATIONAL CONSTRUCTION SECTOR GOALS

## INDUSTRY STRATEGIES FOR IMPLEMENTATION

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Prepared for:  
Subcommittee on Construction and Building  
National Science and Technology Council

Under contract to:  
Building and Fire Research Laboratory  
National Institute of Standards and Technology

By:  
CIVIL ENGINEERING RESEARCH FOUNDATION  
Washington, D.C.

July 1995



U.S. Department of Commerce  
Ronald H. Brown, *Secretary*  
Technology Administration  
Mary L. Good, *Under Secretary for Technology*  
National Institute of Standards and Technology  
Arati A. Prabhakar, *Director*



## Notice

This report was prepared at the request of the National Science and Technology Council's Subcommittee on Construction and Building under contract number 50SBNB56C8506 to the Building and Fire Research Laboratory, National Institute of Standards and Technology. The statement and conclusions contained in this report are those of the Civil Engineering Research Foundation and do not necessarily reflect the views of the National Institute of Standards and Technology or the National Science and Technology Council.

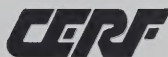


U.S. Department of Commerce  
National Bureau of Standards  
Technology Administration  
1001 DuPont Circle, N.W.  
Washington, D.C. 20535  
Telephone: (202) 335-5000



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Civil Engineering Research Foundation

1015 15th Street, NW . Suite 600 . Washington, DC 20005 . Phone 202-842-0555 . Fax 202-682-0612





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## **I. Introduction**

This report presents initial strategic considerations for a national initiative that is intended to fundamentally impact the quality and productivity associated with construction industry activities in the United States. It specifically provides the "implementation strategy templates" for the residential and public works construction sectors. Similar "templates" for the remaining sectors are expected to be completed during this calendar year; the complete set of sectoral strategies will, in turn, provide an important platform for the industry-led development of an integrated National Plan for the Implementation of Construction Goals, a plan that will fully outline the specific procedures, responsibilities and products that, will, when combined, lead to the realization of the challenging national construction goals that have been postulated and documented through the work of the Construction & Building (C&B) Subcommittee of the National Science and Technology Council (NSTC) and the construction industry.

The Residential Sector implementation strategy (Appendix A) was developed through the leadership of the NAHB Research Center. Members of the development team included representatives of building materials manufacturers, the Building Officials Conference of America (BOCA), the National Conference of States on Building Codes and Standards (NCSBCS), the Civil Engineering Research Foundation (CERF) and the Construction and Building Subcommittee.

The Public Works Sector implementation strategy (Appendix B) was developed as a cooperative effort involving the American Public Works Association (APWA), the Rebuild America Coalition, the Infrastructure Technology Institute (ITI) and CERF.

## **II. Background**

The genesis for this report resides in the critically important, on-going work of the C&B subcommittee and concurrent construction industry input as primarily captured in the conclusions from two events, an April, 1994 industry session on innovation and a December, 1994 White House-Construction Industry Workshop on national construction goals. The April, 1994 session reviewed the initial C&B subcommittee concept of national construction goals, concluding that these goals, including:



- ☐ 50 % reduction in project delivery times;
- ☐ 50 % reduction in operations/maintenance/energy costs;
- ☐ 30 % increase in facility comfort and productivity;
- ☐ 50 % fewer building-related illnesses and accidents;
- ☐ 50 % less waste and pollution;
- ☐ 50 % greater durability and flexibility, and;
- ☐ 50 % reduction in job-related illness and accidents for construction workers

made sense if they:

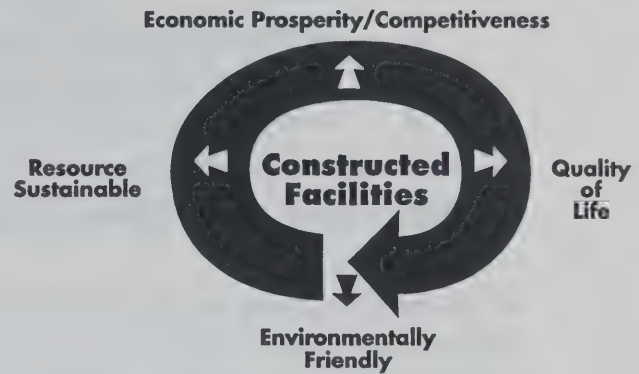
- ☐ were clearly achievable and clearly articulated;
- ☐ anchored in reasonable implementation schemes;
- ☐ targeted "viable" initial (first) users, and;
- ☐ embedded appropriate incentives and recognition

The December 1994 workshop benefitted from the more detailed analysis of the proposed national construction goals via the five major sectors that generally encompass the vast range of construction activity in the United States, namely residential, industrial, commercial, institutional and public works. The most important workshop conclusions were that the proposed construction goals made sense, are needed but, would vary significantly in relevance among the five sectors. As a consequence, the workshop concluded that a single focused construction industry "template" for national construction goals implementation would be an impossibility to either develop or execute. What was needed and could, in fact, attain the desired goal results was a sector-focused approach that enables the focused application of sectoral expertise to develop, prioritize and execute the sector relevant goals. Workshop attendees agreed that the future competitiveness of the U.S. construction industry needed the "vision of excellence" that is implied in the proposed goals and, specifically, that each sector within the industry had to commit itself to undertake very significant actions in order to pull together the diverse, even contentious, interests present in each sector.

In sum, for any progress to be made towards implementation of national construction goals would require, from each sector and from the construction industry as a whole, that:

- ☐ industry leaders provide the necessary leadership and substantial resourcing;
- ☐ the respective sectors organize to "succeed;"
- ☐ a viable industry oversight body be established, and;
- ☐ barriers to innovation be recognized as an initial priority.

### **Constructed Facilities Vision**



These goals are, themselves, the measurable, operational parameters in a process that has, at its center, a firm vision of what our constructed facilities should comply with and contribute to the nation. This is depicted in Figure 1.

**Figure 1**

Vision attainment implies a process. This process is depicted in Figure 2.

While goals are depicted in Figure 2 primarily in terms of their development sequence in the process, the goals are central to the derivation of potential benefits, to the development of the strategy for their attainment and, finally, to the choice of implementation methods. The strategy for any sector may, of course, include the periodic reassessment and refinement of goals.

### **Construction Industry Vision**



**Figure 2**



Due in large part to the work of the C&B subcommittee, the foundation for a constructed facility vision has been emplaced. These foundation pillars include:

- ☐ quality in all constructed facilities;
- ☐ energy efficiency, environmental compatibility and sustainable resource usage;
- ☐ intelligent renewal of existing public/private infrastructure components through effective use of scarce material and human resources, and;
- ☐ innovative measures to mitigate impacts of natural and man-made hazards.

### **III. Next Steps: A Pathway for Progress**

The as yet developing constructed facility vision, the process outlined for goal attainment and the vision pillars provide an important conceptual platform for the development of the individual sectoral strategies and the eventual national implementation plan that will links the sectoral strategies into a cohesive national initiative. Action is underway in all sectors towards the end objective. As expected, the sectors that have the strongest existing linkages and identity have achieved the most. As a result, their "concept" sectoral strategies for implementation of construction goals have been completed and are the initial components of this report. Even for these sectors, residential and public works, work remains, a testimony to the significant challenges that underlie a simple and compelling premise: that national construction goals are essential and must be undertaken for the long-term benefit of the nation and the construction sector.

Stated simply, the fundamental approach will be to let success breed success. The progress, to date, in the residential and public works sectors will be the essential leverage for progress in the industrial and commercial/institutional sectors. Through the active facilitation and coordination (but not unilateral leadership) activities of the Civil Engineering Research Foundation (CERF), the set of sectoral strategies will be fully developed and, equally important, the critical implementation plans of the respective sectors will be melded into a cohesive national plan. It is planned that the intra-sector facilitation and coordination of both sectoral strategies and implementation plans will be facilitated through an oversight council with broad "stakeholder" participation. The development and execution of these activities is programmed over the remainder of 1995 and early 1996. Underlying this upper level of national goals implementation will be the focused activities within each sector, with special emphasis on the sharing between sectors of both successful and problematic approaches towards goal attainment.

The United States and its construction sector must forcefully address the fundamentals deemed as essential in the current and projected domestic and global milieus; the nations who will prosper are those whose economic components:

- ☐ have superior intelligence (i.e., knowledge bases);
- ☐ are capable of managing advanced technologies;
- ☐ respond rapidly to change, and;
- ☐ accomplish the above functions with cost effectiveness

The sectoral strategies and the implementation plans that will emerge through this national initiative recognize the pivotal role of constructed facilities in enabling the nation to meet these fundamentals.





# **APPENDIX A**

## RESIDENTIAL SECTOR IMPLEMENTATION STRATEGY





## **APPENDIX A**

### **Residential Sector Implementation Strategy**

#### **Introduction**

The residential building industry is one of the largest and most important sectors of the U.S. economy. Residential buildings and improvements accounted for 44.3 percent of the value of all construction and 4.1 percent of the total U.S. gross domestic product (GDP) in 1993. In the U.S. economy, however, housing not only is a product that provides essential services related to shelter, but is a chief form of personal investment and savings for many households. The so-called gross housing product, taking into account such investment by including the imputed value owner-occupied housing and rents, amounted to 12.1 percent of the U.S. GDP in 1993. According to the U.S. Congress' Office of Technology Assessment, new residential construction represents almost 25 percent of the total GDP when industries related to homebuilding are included in the housing production chain.

Despite the importance of the housing industry, however, its expenditures on research and development (R&D) of about \$359 million annually, is only about 0.2 percent of the total value of new residential construction put in place, considerably lower than that spent by the construction industry as a whole and most other sectors of the U.S. economy. Moreover, a strong connection exists between productivity, industry structure, and the level of R&D expenditure. A recent study asserted that the increase in labor coefficients that occurred in the housing industry since 1969 was indicative of a decline in productivity. Other studies have demonstrated that productivity has been stable or that growth has been lower than that of most other industries.

The fragmented, unorganized approach to U.S. residential construction technology transfer tends to create significant gaps between development and application of worthwhile technologies. Key problem areas recently identified by a roundtable of builders and building product manufacturers included insufficient product information, poor manufacturer understanding of the building process, alternative building product/system uncertainty, "green" building product confusion, and deficient training support. The roundtable reinforced the Research Center's finding in its study of housing innovation that building material manufacturers are too far removed in the production chain from the building process to understand the needs of home builders and their customers.



The home building industry is lagging in the adoption of modern management techniques such as total quality management. Quality experts have estimated that if these techniques were adopted throughout the industry, the return to the industry and the economy of the U.S. could be well over \$20 billion per year. This innovative management process is one of many technology-transfer subjects that will improve residential construction productivity.

The residential working group, cognizant of these conditions, reviewed and discussed all seven national construction goals and clearly identified as its first priority reduction in delivery time or first cost. Its second priority was improvement in durability. Both goals were felt to be important in improving the productivity of the housing industry. Actions that can facilitate the flow of existing innovation (including regulatory and institutional reforms) in the housing production chain are necessary to encourage private sector investment. They were, therefore, accorded the highest priority in achieving these goals. As a whole the group felt that the Manufacturing Extension Partnership program was an ideal mechanism for accelerating the achievement of the two goals.

## **GOAL 1: 30% REDUCTION IN FIRST COST**

There are two components to the approach to this goal. The first is reduction in cycle time, and the second is reduction in building product and system costs. Both are equally important to the achievement of the goal.

### A. Reduction in Cycle Time

Given the state of current technology, an ideal but achievable construction cycle-time goal for on-site builders is 63 work days for a 2,000 square foot house from foundation excavation through finishing work and presettlement. This goal is derived from a pilot benchmarking study of best-practice construction cycle times of innovative, on-site home builders and modular housing manufacturers. A recommended ideal but realistic construction cycle time for modular builders is 28 work days, a 56 percent reduction in the number of work days required to site build the house under the most favorable conditions. Other industrialized housing systems such as panel were not a part of the study, but would be expected to be somewhere in between site built and modular construction.

The Department of Commerce collects data on construction time by number of months from the time excavation begins for the footings or foundation to the time when all finish flooring is completed, about comparable to the time period used in the pilot study. For single family construction the average time to completion is 4.9 months (1994 data). Based on an average 22-day work month, this equates to approximately 108 days for a national average. Obviously, this is substantially longer than the 63 work day goal.

Innovative builders combine a variety of new process-oriented management techniques with innovative technology to overcome barriers to rapid construction. For complex operations with multiple sites, innovative builders expedited operations by daily rather than weekly tracking of operations, problem-solving and schedule adjustments. Expedited operations took advantage of computers and telephone and facsimile interconnection services which automatically and instantaneously updated project status, scheduled activities concurrently, reduced gaps between subcontractor activities, and used just-in-time procedures effectively. Shorter cycle times were associated with improved quality and increased customer satisfaction, which led to more customer referrals, an improved builder reputation, and greater profitability.

Improved management processes and methods, by shortening construction cycle time, also reduce costs associated with interest on construction loans, administrative overhead, legal procedures, and vandalism. Although the cycle time study referenced was limited to the construction cycle, the regulatory process was identified as adding substantial time to the total required in the residential process. In addition, the financial processing cycle is also significant.

#### Potential Areas of Investigation For the Reduction of Cycle Time

1. Develop systematic construction planning and scheduling programs that could be used by builders of varying levels of sophistication in tracking construction progress and measuring actual versus targeted construction times for various stages of the construction process from design to closing. Integrate as a component of such programs the capacity to identify problems and quantify cost savings or losses associated with time reductions or delays. Review and evaluate existing methods and techniques for planning and scheduling, outlining their advantages and disadvantages for application in the home building industry.
2. Work with local building inspectors, code agencies, and state governments, to develop and demonstrate fast-track permitting and plan review processes. Evaluate the results of such demonstrations and develop a model fast-track approval process including model ordinances and legislation, that could be adopted by local and state entities. Review fast-track permitting and plan review processes established in parallel fields of government such as construction of nuclear plants, international trade agreements, etc. for their applicability to the home building industry.
3. Work with federal, state, and local communities to develop and demonstrate expeditious environmental, land subdivision, zoning, and community planning reviews and approvals. Evaluate the results of such demonstrations and develop



model amendments or changes to administrative regulations, ordinances, and legislation that could be adopted by federal, state, and local communities to speed the time-consuming portion of the development process that occurs prior to breaking ground for construction. Review examples of such approval processes in the federal state and local levels intended to facilitate such approval processes for their applicability to the home building industry.

4. Develop a competitive awards program for reduction of the cycle time of construction, and transfer the results from award winners to the home building industry at large through seminars and workshops.
5. Conduct investigations of technology innovations that could lead to reduction in cycle time delays associated with inclement and adverse weather conditions. For example, methods of reducing the curing time for poured-in-place concrete in foundations, plastic and other enclosures to protect buildings under construction, weatherproof electric conduits, etc.
6. Work with financial institutions, insurance companies, etc. to reduce the time it takes to "close" on a house. Investigate ways of reducing the costs associated with closing.
7. Develop interactive systems and methods of transfer of information that will aid builders in choosing and specifying appropriate materials, technologies, and energy conservation measures in designing the house and estimating the costs of construction. Develop programs that link computer-aided-design (CAD) directly with cost estimation, subsequent ordering of materials and components, and their sequencing of assembly at the site through bar-coding.
8. Develop methods of reducing the time involved in ordering, distributing, and replacing various materials and components used in the construction of the house with a view to reducing the inventory of materials at the site and coordinating delivery with the stages of construction.



## B. Reduction in Building Product and System Costs

Innovative building products and systems are developed by individuals, private industry, the nation's universities and occasionally by the U.S. Government or with some government support, particularly NIST, DOE, and HUD. Historically, adoption of innovations by the construction industry has been painstakingly slow, causing some potentially important innovations to drop out of the process prior to builder acceptance. In addition, because of the high cost of innovation, new technologies typically gain acceptance first in upper income housing and are slow to penetrate the market for affordable housing. Rather than provide aid in sponsoring more innovation for the housing industry, efforts to reduce costs should focus on providing support to bring cost-saving innovation more quickly to market in the fragmented housing industry.

A significant contribution might come from efforts to disseminate technology through demonstration programs and technical support. For the nation as a whole, a relatively small investment in applied housing technology demonstrations can leverage large benefits and thereby contribute significantly to the nation's productivity and well-being. Such demonstrations should encourage the use of existing innovative technologies and creative management approaches of cost-saving building products and construction systems that are already on the market but have not achieved significant penetration.

### Potential Areas for Reduction in Building Product and System Costs

1. Continue and expand efforts initiated under the National Institute of Standards and Technology Manufacturing Extension Partnership (MEP). In 1988, Congress directed NIST to create regional centers that would assist in speeding the transfer of advanced technologies to U.S. industry. The MEP program builds linkages between various building industry participants to help remedy gaps in communication of technical information, a leading problem in the building industry.

The specific goal of the MEP is to develop a number of comprehensive multi-state regional housing technology resource centers that link existing and new sources of technical assistance and information services to serve small- to medium-sized home builders, subcontractors, suppliers, and building product manufacturers. These centers, by providing an information clearinghouse and other services, could help the home building industry adopt useful, cost-saving technologies and advanced business practices that would enhance the competitiveness of the U.S. housing industry by lowering first costs and improving housing affordability, productivity, and quality.

A relatively small investment in applied housing technology transfer can leverage large benefits. In order to encourage the use of innovative building products and construction systems and creative management approaches within the residential construction industry, linkages between providers of technical assistance aimed at housing and light construction should be established. Federal assistance is needed because fragmentation precludes a sufficiently large investment by the building industry itself. The U.S. Government is a primary stakeholder in a strong, vital shelter industry since it represents a relatively large percentage of the GDP and labor workforce and because decent affordable housing for every American is a recognized national goal.

2. Focus a demonstration program on regulatory and technical innovations that impact the costs of construction or operation of buildings. Regulatory relief could come from federal, state, and local levels of government. Technical innovations will need the support of state and local code officials and, in some cases, the model code bodies. The long lead time involved in land development might exclude its consideration in the first set of projects. The projects need to reflect regional differences in major market areas. Government funding will be necessary to support staff time for such activities as identifying burdensome regulations, working through the regulatory process, identifying technical innovations and land development techniques, and documenting cost savings.
3. Continue the project being conducted by CERF focused on developing a nationally and internationally recognized system for evaluation and acceptance of innovative construction products and services.

## GOAL 2: 50% INCREASE IN PRODUCT DURABILITY

Despite the relatively low level of technological advancement in houses built 50 or more years ago, such houses constituted 23 percent of the existing housing stock in 1990. Although many components in these homes have since been added or replaced, the original foundation and structural frame typically remain in place. In addition, the average life of some housing components has increased during the past 20 years because of innovation and the introduction of new products, even as the life of other components has declined.

Product durability is clearly the result of many factors, including design, materials, manufacturing technology, and consumer willingness-to-pay. In many instances, durability may be affected by how a given product is installed, used or maintained. In addition, some products remain functional but become obsolete due to changing styles, tastes, or new technology.

What follows is a series of suggested activities aimed at more clearly defining the scope and nature of a "durability" goal, specifying the technical issues and needs, and promoting improvements in areas that will increase product durability. Not all items in the list are strictly necessary, but they are ordered in a sequence such that earlier items in the list provide focus and direction for subsequent items in the list.

### Potential Activities to address Increased Product Durability

1. Review existing information or develop new information about the historical determinants of functional lifetimes of residential buildings and the factors that have led to their removal from the housing stock, such as catastrophe, long-term progressive deterioration, and factors other than physical deterioration.
2. Identify the principal housing systems, components and materials of potential interest from a durability standpoint, such as foundation systems, framing, roof coverings, wall coverings, plumbing systems, mechanical systems, fasteners, floor coverings, windows and doors, paints and coatings, water heating and thermal protection. Narrow the list or prioritize items within the list to identify home building products and materials of particular interest for further investigation.
3. Identify and inventory existing test methods developed by ASTM, ANSI or similar consensus-oriented bodies, or published by organizations such as trade associations, that measure, quantify or evaluate the durability of specific home building products and materials of interest. Determine the underlying theories or approaches that are used to assess durability, e.g. accelerated aging, or resistance to various kinds of



weather or environmental agents. Coordinate this work with related international standardization activities.

4. Identify and inventory existing standards for home building products and materials of interest that include minimum durability requirements. Include model building codes and referenced consensus standards, federal specifications, voluntary industry standards, and manufacturer warranty practices. Determine the range of product lifetimes found in these sources, by product type. Identify any other information on appropriate product lifetimes, such as consumer expectations or non-functional obsolescence. Coordinate this work with related international standardization activities.
5. Identify gaps in applicable test methods as applied to home building products and materials. Define and perform research on a product-type basis to investigate improved standard methods for testing and quantifying durability. This research should be based on what is known about contributors to durability in service for each type of product, which will depend on where and how the product is used. It should also reflect what is known about significant failures of building products currently in use.
6. Assess opportunities to promote improved durability above and beyond levels required in model codes, through market-oriented approaches. Possibilities include comparative advertising, information disclosure requirements, and independent third-party testing or reporting similar to the Consumer Reports approach.
7. Assess opportunities to promote improved durability by incorporating performance requirements into product standards that do not currently address durability. Durability performance would need to be quantified by existing or new test methods that are scientifically based and generally accepted. Minimum durability standards or pass-fail criteria should initially be based on current "good practice" by product category or sub-category, and set through consensus methods.
8. Assess opportunities to promote improved durability through information and education aimed at occupants, encouraging proper use, regular preventive maintenance, and timely repair.



# **APPENDIX B**

## PUBLIC WORKS SECTOR IMPLEMENTATION STRATEGY





## **APPENDIX B**

### **A Public Works Sector Implementation Strategy**

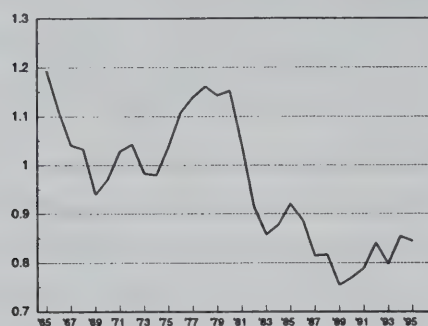
#### **Introduction**

The public works infrastructure in the United States has been characterized as a "local problem with national consequences." The local characterization is an apt one, inasmuch as the bulk of our public works infrastructure is in the hands of the approximately 10,000 cities and counties that stretch across the nation. The "national consequences" characterization is likewise appropriate since the condition of the nation's public works infrastructure markedly impacts the economic efficiency and, increasingly, the global competitiveness of all other economic activity in the United States as well as the quality of life of our citizenry. The ability to transport goods and people safely and efficiently, provide adequate water resources, treat wastewater, dispose of solid and hazardous waste, provide excellence in education, public administration and quality in health care has been the gateway for U.S. economic advancement in the past and is even more essential as the nation stands at the threshold of a new, more complex century. In spite of these facts and recognized needs, the past several decades have been a time of underinvestment in the U.S. public works infrastructure. A series of public and private reports document this disturbing fact; the most recent reports include the 1995 report by the U.S. House of Representatives' Committee on Transportation and Infrastructure and the 1995 Economic Policy Institute (EPI) assessment, entitled *The Case for Public Investment*. In this latter report, several important observations are made with respect to the linkages between investment in public works infrastructure and productivity and, the disturbing fact that the United States has been a serious under-investor vis-a-vis its principal international competitors.



As already stated, the levels of investment in public works infrastructure as a per cent of U.S. Gross Domestic Product (GDP) have, except for a brief respite in the 1970's, plunged; this decline is presented for the Federal Sector in Figure 3, in which a thirty years' investment history is depicted.

**Thirty Years of Federal Investment in Infrastructure  
1965-95**

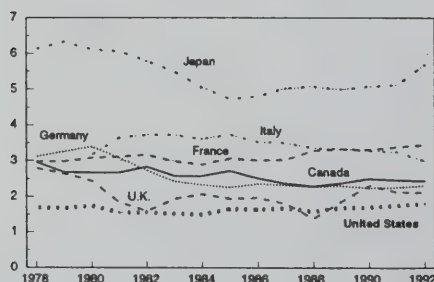


Source: EPI calculations using OMB data

**Figure 3**

The EPI report proceeds to note that the same pattern has been evident in state and local infrastructure since the 1980's, due in part to the fact that significant Federal funding is used to finance state and local public works infrastructure investment. This decline in investment is doubly disturbing when viewed in relation to the public infrastructure investment undertaken by our primary global economic competitors. Here again, the trend is more dramatically presented when viewed graphically, as in Figure 4.

**Public Infrastructure Investment  
in the G-7 Countries**

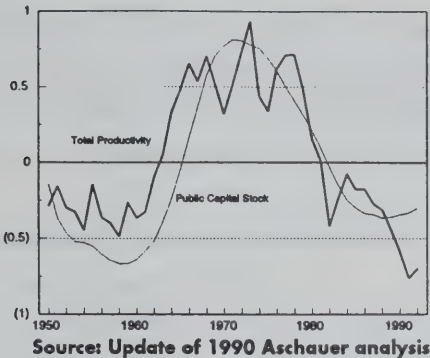


Source: OECD, 1992 and 1994

**Figure 4**

The bottom line that emerges from the EPI report is simply this: the physical "health" and capabilities of the public works infrastructure impacts the economic "health" of the nation. This "inter-dependence" is more compelling when portrayed graphically, as shown in Figure 5.

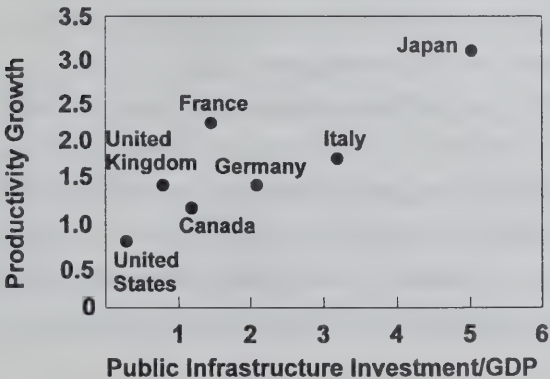
**Public Capital Stock and Productivity  
1950-92**



**Figure 5**

That this "interdependence" of public investment and productivity is a globally valid factor is clearly shown in Figure 6.

***Public Investment and Productivity  
in the G-7 Countries (1978-1990)***

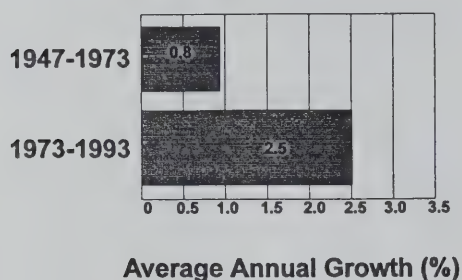


**Figure 6**

Finally, it is increasingly evident that productivity growth and public investment are linked. The U.S. experience since the end of World War II is captured in Figure 7.

### ***Productivity Growth Pre-1973 vs. Post-1973***

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Source: EPI analysis of CEA data

**Figure 7**

It is clear that the importance of our public works infrastructure cannot be overstated; therefore, in these waning days of the 20th Century, the condition and operation of our public works infrastructure must become a matter of extreme concern to all. In many jurisdictions, especially older urban areas, aging infrastructure components, coupled with limited ability to maintain, let alone operate, is the norm. Even in more affluent suburban areas, the operation and maintenance of infrastructure as well as the high cost of capital improvements must compete with the growing demand for social services. Moreover, it is increasingly apparent that the emerging global environment of the 21st Century will favor those nations whose public works infrastructure enable and enhance the most efficient production and distribution of goods and services.

How can the significant, recognized public works needs be met so that the nation's public works infrastructure can support the needs of our increasingly complex, globally dependent society? A significant component towards resolving this issue is the development of an effective, cross-cutting national public works strategy, anchored in well-defined goals and broad public and private support. The critical components of this strategy are outlined in the sections that follow; these components build and depend upon harnessing the vast, existing expertise represented in both the public and private sector including various Federal, state



and local public agencies, the private sector (industry), various trade and professional associations and the nation's excellent academic community. In fact, the development of a strategy for national construction goals in the public works sector depends more on the effective integration and optimal utilization of the resources that now exist than upon the creation of new entities that might compete for already scarce resources.

Much of the nation's infrastructure is capable of supporting current and projected requirements; unfortunately, this cannot be said for all components or jurisdictions. A recent synopsis by the Rebuild America Coalition reinforces the need for both concern and coordinated action; some specific current statistics include:

- ✓ almost a quarter million miles of our highway system is rated as in poor or mediocre condition
- ✓ one third of the nation's bridge stock is either structurally deficient or functionally obsolete; more than twenty-five percent of all bridges are more than fifty years of age
- ✓ mass transit suffers from both overage rolling stock and poorly maintained facilities; moreover, the extent of mass transit services fails to meet current and projected needs
- ✓ air traffic is projected to grow by over one half over the next decade; the severe congestion that currently afflicts major airports is expected to more than double if new runway capacity is not emplaced
- ✓ the nation's water resources, both supply and wastewater treatment, require an estimated \$200 billion over the next two decades to simply meet regulatory requirements
- ✓ both solid and hazardous waste have major disposal and cost consequences

The Rebuild America Coalition estimates that as much as \$1.1 trillion is required over the next 15 years to provide a minimally satisfactory public works infrastructure. Clearly, an expenditure of this magnitude requires the development of an effective strategy to ensure that scarce resources are most effectively used in both planning and implementation.

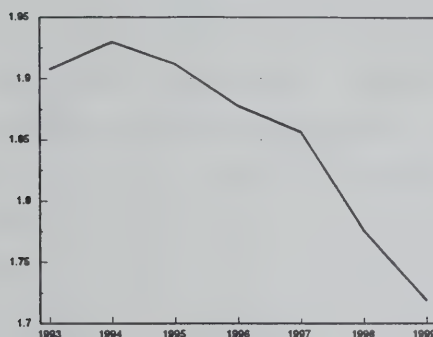
The strategy developed herein envisions the active participation of the nation's broad public works infrastructure constituency. Immediate leadership, however, is being exercised through the focused participation of the American Public Works Association (APWA), the Rebuild America Coalition, the Civil Engineering Research Foundation (CERF), and the Infrastructure Technology Institute (ITI).

Many of the prerequisites for a successful national public works construction goals initiative are present in the various institutions and programs that now comprise a public works "process." With respect to this "process", the following is noted:

- ☐ while mechanisms exist within excellent organizations, such as the American Public Works Association (APWA), the Rebuild America Coalition, the Infrastructure Technology Institute (ITI) and the Civil Engineering Research Foundation (CERF) for exchange of various data, including data on research and innovation
- ☐ the public works community, in general, recognizes the need for cost effective innovative technologies
- ☐ a large community of public works focused manufacturers and suppliers exists
- ☐ many entities are increasingly interested in helping resolve state and local public works needs
- ☐ in spite of these favorable indications, **a significant breakdown is apparent between willingness within public works agencies to innovate and effective actions to move innovative technologies into practice**, due to:
  - ☐ largely uncoordinated efforts, lacking a clear vision
  - ☐ lack of effective linkages between the key stakeholders
  - ☐ little apparent time and resourcing within the public works community to consider how to improve upon current operations
  - ☐ the general nation-wide unfamiliarity regarding public works problems and needs
  - ☐ the general lack of procedures in local public works agencies that accommodate introduction of innovative technologies
  - ☐ lack of funds

The last factor, lack of funds or underinvestment, has been effectively shown by EPI as a principal reason for the current condition of the public works infrastructure. As Figure 8 shows, the projected Federal investment in the nation's physical capital, if realized, may accelerate the downward spiral in the quality and quantity of the public infrastructure. This potential, alone, is a compelling reason for the rapid development of a national public works construction goals initiative.

**Total Federal Investment Outlays  
1993-99**



Source: EPI analysis of OMB data

**Figure 8**

In summary, while the nation has a need to implement viable construction goals in each sector and, in doing so, the quality of life and economic opportunities will be advanced, it is more and more apparent that the essential link that will enable these sectors to achieve their respective goals is our public works infrastructure. Goal attainment in the public works sector is therefore a doubly important national objective.





### III. The Public Works National Goals Implementation Strategy: An Overview

As stated earlier, the strategy for attainment of appropriate public sector construction goals does not depend upon the creation of new entities as much as upon the effective integration, use and strengthening of existing venues. This is an important consideration and reflects the growing consensus within the public works sector that national construction goals is a natural progression that adds vision and purpose to the many actions that are currently underway in the public works community to ensure the creation or revitalization of the public works infrastructure. This understanding of the role and purpose of the construction goals initiative will enable these goals to gain broad acceptance and inclusion in the broad spectrum of current public works activity. As noted earlier, the leadership role for **introducing** construction goals into the public works sector has been jointly accepted by four organizations who, collectively, bring together a large part of the diverse communities whose commitment and participation is essential for success. This initial leadership commitment does not exclude the active future leadership role of others; indeed, it invites the active commitment and participation of all whose impact will further the attainment of the construction goals that become the consensus priority goals for the sector.

Several venues are viewed as especially important for program success, primary among them the excellent structure that exists in the American Public Works Association (APWA). The strategy therefore builds upon most of the institutes that have been created by APWA as the specific venues for attaining important goal objectives. The specific institutes include:

- Water Resources
- Solid Waste
- Transportation
- Buildings and Grounds
- Equipment and Services
- Management
- Municipal Engineering

Moreover, the annual APWA International Public Works Congress is viewed at this time as one of the most appropriate and visible focal points for the construction goals initiative. Through the Congress, an annual venue is provided for overall program objectives, including but not limited to:

- ☐ interaction with national leadership, agencies, etc.
- ☐ goals progress reports
- ☐ goal validation, refinement and/or revision
- ☐ consortia creation for specific products
- ☐ resourcing
- ☐ strategy development for specific goals or products
- ☐ public outreach
- ☐ focused exchange on program goals with other construction sectors

The many other venues offered by the APWA structure will likewise be used as appropriate in the development and execution of the public works goals strategy.

Important links are also provided by the other initial leadership group members. For example, the significant research capabilities found in hundreds of universities across the nation must be stimulated to address public works infrastructure needs in a more effective manner than is now the case. The role of the Infrastructure Technology Institute (ITI) makes it particularly well suited to accomplish this. Likewise, the commitment and potential impact of the construction industry and its many professionals must be captured; the efforts of the Civil Engineering Research Foundation (CERF) and its parent organization, the American Society of Civil Engineers (ASCE) provides one important venue for this. Finally, the focused outreach to the national leadership and the American public that is represented in the Rebuild America Coalition represents an invaluable communications and outreach link for this strategy.

These four organizations will not be able to implement public works construction goals by themselves. They are the nucleus, designed to encourage and enlist the commitment and participation of the hundreds of other public works focused organizations whose combined ideas, skills and resources can achieve this!

Five major components comprise this draft public works national construction goals strategy; these components are summarized as follows and presented in more detail later. Full development of these strategy components is envisioned to be accomplished in the public works implementation plan.



☐ **Establishing Essential Public Works Linkages**

- ☐ stakeholder identification/inclusion strategies
- ☐ federal sector interaction/coordination
- ☐ academic participation
- ☐ industry participation

☐ **Identification, Validation and appropriate Revision of Public Works Infrastructure Goals and Products**

- ☐ national public works condition inventory
- ☐ continuous public works problems and needs assessments
- ☐ goals review, revalidation and prioritization
- ☐ public works product development, validation and implementation

☐ **Technology Requirements Assessment and Development**

- ☐ benchmarking "best" practices, using 1994 as baseline
- ☐ key technology "needs" identification
- ☐ technology needs alert
- ☐ innovative technology assessment/evaluation

☐ **Program Development and Execution**

- ☐ development of achievable product timelines
- ☐ consortia development
- ☐ demonstration strategies
- ☐ funding: requirements and sources
- ☐ barriers identification and mitigation
- ☐ data bases/communications

☐ **Program Coordination, Information and Public Affairs**

- ☐ oversight structure and participation requirements
- ☐ training/education
- ☐ national leadership participation/buy-in
- ☐ public outreach for program support



## **IV. Establishing the Essential Public Works Linkages**

The U.S. public works arena has many stakeholders, ranging from elected and appointed officials, materials and equipment providers, public works operators to the American public, the ultimate user and beneficiary (or, at times, victim) of the scope, quality and efficiency of products and services.

This strategy component is addressed first because the successful execution of public works construction goals will hinge upon its effectiveness. In this step, critical linkages are established (or strengthened), both within the public works community and with essential external organizations. Goals achievement will depend upon the ability to both generate support for such goals and the existence or creation of venues for goal execution; both will depend upon these linkages. This component is therefore an initial priority in the public works strategy for construction goals. Unlike the other sectors, public works infrastructure ownership belongs to the nation, albeit, with some exceptions, in the small doses that represent our thousands of cities, towns and counties. More so than for other sectors, the active involvement and commitment of the public at large is needed to ensure goal attainment. This component will therefore strive to establish strong links, anchored in a common vision for public works, and establish the framework for coordinating and leveraging the activities of the public works community itself, the Federal sector, academia and the private sector, especially the construction sector but also the other sectors of the economy whose efficiency and competitiveness is directly linked to an effective public works infrastructure.





## V. Identification, Validation and Appropriate Revision of Public Works Infrastructure Goals and Products

Goals are the focal point of this initiative. As such, it is imperative that these goals be precise, significant and attainable. To facilitate this will require:

- continuous public works problems and needs assessments
- goals review, revalidation and prioritization
- public works product development, validation and implementation

One important outcome of the December 1994 national construction goals workshop was the identification of priority goals, by sector. Thus, for the public works infrastructure, three of the seven proposed goals were selected as the most relevant and significant (see Figure 9).

C&B Goal	Residential	Commercial	Institutional	Industrial	Public Works	RANK
Delivery Time	✓+	✓	✓+	✓+	✓	1
Operations Maintenance & Energy Use	✓	✓+	✓	✓	✓+	2
Productivity		✓	✓			5
Occupant Health/Safety	✓					6
Waste/Pollution	✓				✓	5
Durability/Flexibility	✓+	✓				3
Workers Health/Safety	✓		✓	✓		4
✓ = Priority      ✓+ = High Priority						

**Figure 9**

It is important to recognize that this prioritization did not imply that the remaining four goals were unimportant, only that initial focus should be placed on these three, including:

- reduction in operations, maintenance and energy costs
- reductions in facility delivery times
- reductions in waste and pollution

This component of the strategy addresses the most fundamental aspect of the construction goals initiative; the goals themselves and the "products" developed to achieve these goals. It is therefore, philosophically, the most important of the components. It is also a component that is likely to change over time, as priority goals are attained or as priorities themselves change due to changing societal conditions, technological breakthroughs, etc. The strategy therefore includes the continuous review of the established priorities and appropriate modifications based upon "stakeholder" consensus. The principal venue for this will, in all likelihood, be the annual APWA International Public Works Congress, during which current priorities can be reviewed and modifications proposed.

Execution of the priority goals will entail the evaluation and integration of a formidable set of factors, including the goals themselves, barriers to implementation, applicable technologies and processes, potential participants, product delivery mechanisms, resource options, etc. The complexity of this effort has been recognized by the C&B subcommittee. The subcommittee has therefore framed goals execution in the form of a set of products that, when widely implemented in any sector, will lead to goal attainment. This approach has merit, and is incorporated as a concept in the public sector strategy. The proposed product list developed by the C&B subcommittee is presented in Table 1; the public works strategy envisions the further evaluation of this product list and appropriate modifications to accommodate the specific needs of the public works sector.

#### ***Proposed C&B Products***

---

- **Leadership for Innovation**
- **Regulatory Reinvention**
- **Skilled Workforce**
- **Baseline Measures**
- **Human Factors**
- **Information Systems**
- **High Performance Materials and Systems**
- **Construction Automation**

**Table 1**



## **VI. Technology Development and Related Requirements**

The technology component tasks have been identified as:

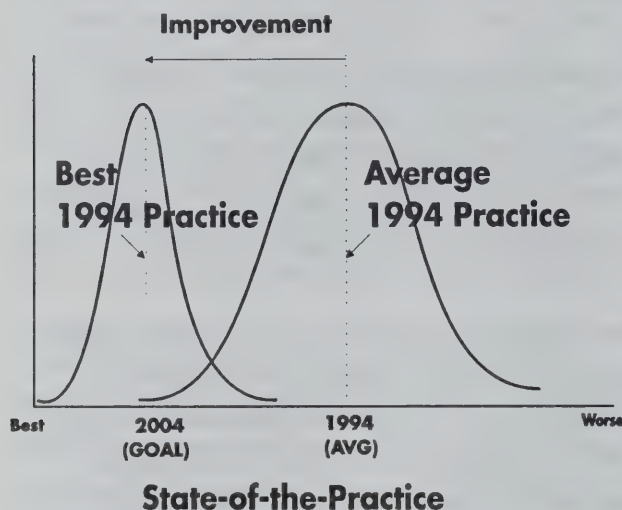
- benchmarking "best" practices
- key technology product "needs" identification
- technology product needs alert
- innovative technology product assessment/evaluation
- standards/codes development

The components of the public works construction goals strategy are, in a sense, distinct "pieces" that require development and precise fitting in order to enable goal attainment. While all are essential and failure of any one component jeopardizes the outcome, it is innovative technology that will provide the essential means for goal attainment. Several important actions are key to ensuring the development of the required technologies.

First, is to establish what constitutes the best current practices in the large and diverse public works community, that is, benchmarking. This task is, of course, focused on the specific goal(s) that has been accorded priority status. In this regard, the public works sector may initially differ from the other sectors, all of whom have indicated that reduction of project delivery time (or a variant but related goal of reduced first cost) is the initial priority goal. The goal of reducing operations, maintenance and energy costs was given top priority by the public works sub-group at the December 1994 workshop, as was indicated earlier in Figure 9.

As already noted, reduced project delivery times and reductions in the generation of waste and pollution emerged as the other priority goals. Benchmarking some aspect of project delivery times, for example, may lead to the conclusion that a significant difference exists between the average practice seen in the majority of instances and the very best, observed in only a few instances; this difference is graphically depicted in Figure 10.

## **Benchmarking**



**Figure 10**

The desired contribution of this specific aspect towards project delivery time goal attainment may be achieving best practice status for everyone by a specific time frame (in this case, 2004) or it may imply the need to shift the best practice itself **and** ensuring this becomes the average practice; note that this shift is not shown in Figure 10.

With the establishment of the formal public works oversight body, these initial priority goals will be considered and modified, if deemed appropriate. Benchmarking only priority goals is a wise use of scarce resources; other goals will likewise be benchmarked as they become priority goals. Benchmarking at that point (when a goal is recognized as a priority) will ensure that the then best practices are identified rather than practices that may have been overtaken by technology or process. As appropriate, the benchmarking may consider the best foreign practices in order to ensure that scarce resources are not expended in needless duplication of already accomplished research and development. Once identified, the benchmark practices will be widely recognized, in media, through video, as appropriate,

through regional APWA and other association gatherings and, particularly, at the International Public Works Congress. This will help goal attainment, since benchmark practices may already constitute substantial progress towards the stated goals. Establishing the benchmarks is most logically a function of the respective APWA Institutes, working in conjunction with the technical experts from ASCE/CERF, ITI and academe as well as the many specialty professional and trade associations and, the manufacturers of public works related equipment and systems.

For the priority goal, the essential technology product needs (gaps) will be determined. The product set developed by the C&B subcommittee, modified, if appropriate, by the public sector, provides the template for identifying the required products. This determination is a complex undertaking since each goal comprises innumerable technology related requirements and opportunities. Reducing "operational costs", for example, is linked to thousands of public works actions, many of them inter-related. It can be expected that each need or gap will, in most cases, be expressed in the form of a set of products capable of achieving currently unattainable performance parameter(s).

Once identified, the set of needed products associated with a goal will be given wide dissemination within the research and development community, including academe, the public sector and industry. The product needs (gaps) set becomes, in effect, a challenge to creativity and innovation for the research and development community. It is the "needs" alert for each priority goal. Embedded in the "needs alert" will be market potential estimates, in order to stimulate interest and participation by the commercial product developers, whether designers, equipment or material manufacturers, software firms, etc.

An essential component in the technology development process is impartial evaluation of candidate product solutions, whether process, equipment, or material. Existing venues for evaluation, such as the Highway Innovative Technology Evaluation Center (HITEC) may prove adequate; others may be recognized as required over time. A critically important aspect of the evaluation, however, is that the evaluation should enhance the development of appropriate standards and codes for those evaluated product items that require codes/standards in order to be implemented.





## VII. Program Development and Execution

This component has as essential tasks the following:

- creation of goals oversight body
- development of achievable goal/product timelines
- consortia development
- demonstration strategies
- funding: requirements and sources
- barriers identification and mitigation
- data bases/communications

While innovative technologies may be considered the essential engines for construction goal attainment, the development of effective construction goal management concepts and execution parameters are the essential lubricants. The most impressive technologies are unlikely to make an impact in the absence of a highly effective public works structure for goal implementation.

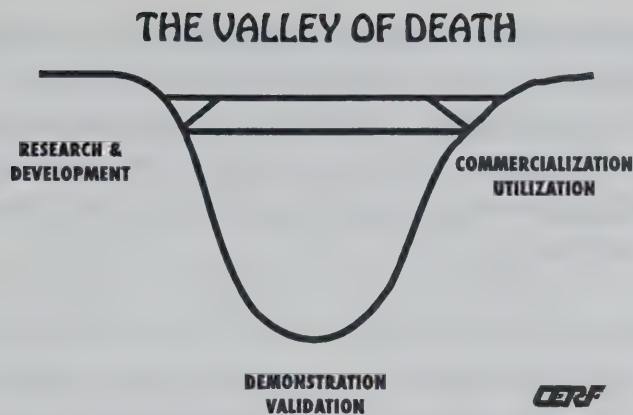
An initial requirement is the establishment of a goals' oversight body that is both visible and widely recognized as the authoritative body for this purpose. While the four initial members of the public works construction goals initiative expect to continue providing their individual expertise until the full spectrum of public works goals are attained, the participation and funding support from all "stakeholders" is a program prerequisite. The active participation and endorsement of all known "stakeholders" will therefore be a program priority effort. A number of venues will be used for this purpose, including the annual APWA International Public Works Congress, the activities of the Rebuild America Coalition, the appropriate venues of ASCE and CERF as well as the many annual academic, association, professional societies and industry venues. The bottom line is an inclusive public works community, focused on the attainment of consensus goals. The public works oversight body will also provide appropriate representatives to the central, multi-sector oversight body for national construction goals implementation, seeking both to transfer appropriate public works success to other sectors and, conversely to learn and benefit from the successful products developed, and implementation actions taken, by the other construction sectors.

Appropriate timelines for goal and product attainment are likewise an essential consideration. These timelines will be developed by consensus procedures by the public works oversight body. Timelines will be coordinated, as appropriate, with the central, multi-sector oversight body in order to maximize the success potential of each construction goal and product.

For the public works sector, consortia are deemed essential for product development and goal attainment. This conclusion simply recognizes the very fragmented and diverse nature of the American public works community. Unlike some of the sectors in the U.S. economy (such as automotive, many consumer product manufacturers and computers) and, perhaps, one of the construction sectors, there are no major "stakeholders" who can, on their own, take on the major resource commitments associated with proposed goals and most potential products. As goals are established and specific products identified for goal attainment, consortia will therefore collectively become an essential public works implementation tool. Consortia creation will require substantial resources and will utilize all possible venues of the public sector stakeholders to disseminate information regarding consortia opportunities, including the increasingly popular opportunities present in such datalinks as the Internet.

A second fundamental program execution requirement will be comprehensive, realistic demonstrations of the products that target the priority public works goals. Consortia membership will be structured to include, from the inception of any specific consortium, those members who will provide the platform for demonstrations/first use. Product commercialization will likewise be a fundamental planning objective; it is therefore envisioned that as many viable potential product commercializers as can be identified will be considered for inclusion in the respective consortia and the demonstrations. Multiple demonstrations, offered by different vendors and site hosts, will be a program target in order to fully stimulate innovation and competitiveness. As with consortia development, all potential venues will be candidates for the development of demonstration programs, but the control and management nucleus for all demonstrations will reside in the consortium or consortia whose focus is the specific demonstration product; the broad supervision of all consortia efforts will be accomplished by the public works oversight body. An important aspect of all demonstrations will be the special focus on enhancing and expediting the standards and subsequent code development for products facing those requirements. The greatest difficulty associated with moving technologies from the research and development phase into commercial use is often found in this phase, which has aptly been referred to as the "valley of death," is shown in Figure 11. The effective bridging of this valley is a primary consortia responsibility.





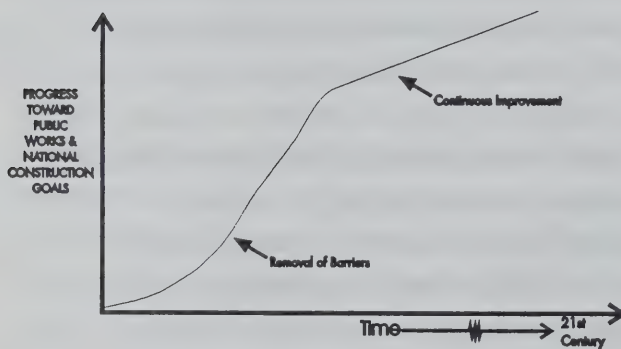
**Figure 11**

No progress towards national public works focused construction goals will be made in the absence of adequate resourcing, including both in-kind contributions and actual funds. Moreover, it is unlikely that public sector funds will, alone, be sufficient or perhaps even available to meet the requirements that will be developed in the comprehensive public works implementation plan. A priority function of the public works oversight body must therefore be not only the development of resource requirements but the obtaining of resource commitments from interested stakeholders, particularly stakeholders with strong benefits potential from on-going product development or goals attainment. One important aspect of this is the clear demonstration to public works agencies and potential vendors that the combined resourcing of important products, through viable consortia, may provide opportunities and results that have heretofore been unattainable by any single entity.

The C&B subcommittee has proposed that a product category be established specifically for the many challenging non-technical "barriers" that, at present, often prevent innovative technologies from being implemented. How these barriers are addressed and surmounted in the public works sector will be a specific responsibility of the oversight body. An important aspect of each product development task will be the identification of known or anticipated barriers and the development of appropriate barrier reduction strategies. An important principle will be the attempt to distribute the risks associated with any barrier so that no single participant is faced with potentially unacceptable consequences.

An important anchor for all project development and execution will be the creation of both a comprehensive data base and the communications links required for its effective implementation and wide-spread use. This data base and the communications link will be the primary operational and archival links among the many stakeholders in the public works community and the input/output linkage between the public works sector and other sectors, as well as other interested or involved entities.

In the end, this public works construction goals strategy envisions a process that becomes a continuous, important and embedded component in the U.S. public works agenda, a process that will enable the consistent and continuous improvement in the effectiveness and quality of the nation's public physical capital, in sum, the creation and sustaining of the world's most capable public works infrastructure. The path that can enable this is portrayed in Figure 12, below.



**Figure 12**

## **VIII. Program Coordination, Information and Public Affairs**

It is likely that one of the primary reasons for the serious investment and quality decline in public works infrastructure that has been experienced over the past quarter century is the absence of a broad public understanding of the role and impact of infrastructure in everyday life. One consequence of this absence is the lack of strong national leadership imperatives in both the Congress and the Administration for excellence and innovation in the public works infrastructure. How can this be changed?

- a strong oversight structure and participation requirements
- hard-hitting, factual training/education
- national leadership participation/buy-in programs
- public outreach for program support

A strong oversight structure involving all appropriate “stakeholders” will be developed to accomplish these tasks.

### **PUBLIC EDUCATION**

The general public, as well as the media, do not see the reason for most of the investment in public works infrastructure because most of the investment is literally invisible to them. Underground water and sewer pipes are usually neglected until they break. Roads, streets, and bridges, once built, are taken for granted by those who travel them, again until they need repair or replacement. For these reasons alone, getting the public to look at the investment in public works infrastructure from a life cycle perspective is a great challenge. Looking at the construction, operation, and maintenance of public works structures and facilities in a holistic manner, seeing the interrelatedness of these physical systems is a goal for the public education component of the Implementation Strategy.

Public support for National Construction Goals in public works needs to be built on a foundation of knowledge and understanding of the importance of public works to the economic, environmental and social well-being of every community. The Rebuild America Coalition, itself a consortium of public and private organizations interested in building broad support for infrastructure investment, will take the lead in developing and transmitting the public education component of the Implementation Strategy. The Coalition is composed of organizations representing local elected officials, supported by organizations representing engineers, builders, financiers, contractors, and architects.



The number one item in the Rebuild America Coalition's mission statement is to:

"create public awareness of the need to increase infrastructure investment and infrastructure's role in building the nation's economy and improving the productivity of the nation."

To achieve this mission, the Coalition undertakes grassroots campaigns at the state and local level. Local Coalitions will work closely with the 58 state and local Chapters of the American Public Works Association to develop and deliver public education programs. This will be facilitated by the fact that APWA serves as the Secretariat for the Rebuild America Coalition.

Four organizations will serve as the points of contact and facilitators for the development of consortia in specific areas:

Organization

American Public Works Association (APWA)  
Civil Engineering Research Foundation (CERF)  
Rebuild America Coalition  
Infrastructure Technology Institute (ITI)

Constituency

Local public works agencies  
Industry, consultants  
State & local government  
Academic research  
organizations

Representatives of each of the four lead organizations will meet as follows:

July 1995:    Develop materials to send to various constituencies  
                 Identify key members of constituencies  
                 Design oversight/coordinating body/invite members  
                 Meet with NSTC representatives

August 1995:    Review survey responses  
                 Organize meetings at APWA Congress  
                 \* individual constituencies  
                 \* oversight coordinating body  
                 \* Federal NSTC representatives

September 1995: Meet at APWA Congress (Dallas)

- \* validate goals
- \* prioritize goals
- \* announce goals/implementation program

Following the APWA Congress meeting, there will be monthly meetings of the public works oversight group. The purpose of these meetings will be to monitor progress, facilitate coordination, maintain communication with NSTC, and develop the final implementation plan in time for the APWA Congress in Washington, DC (August, 1996)

## LOCAL PUBLIC WORKS AGENCIES

APWA will be the lead organization to develop strategies to implement the National Construction Goals for the local public works agencies. APWA will utilize its national organizational resources such as its 7 Institutes for Professional Development, its 58 U.S. Chapters, the APWA Reporter Magazine, and the APWA Electronic Bulletin Board (BBS).

In a special sector of the APWA BBS, hundreds of local leaders in each of the various functional areas (transportation, water supply, wastewater treatment, solid waste collection and disposal, etc.) will have the stated goals from the December 1994 workshop. They will be asked to provide their agency's comments via electronic survey. The results of the surveys will be analyzed and summarized by an APWA committee. The results will be disseminated to all local public works agencies.

In cooperation with the Rebuild America Coalition, all local efforts directed at public education regarding investment in public works infrastructure, understanding the nature and importance of infrastructure will be coordinated. A national clearinghouse of public educational materials and programs will be established under the auspices of the public works oversight group.

Training/education, national leadership participation/buy-in and public outreach will benefit from the very extensive mechanisms already operational in the public works sector. The emphasis will therefore be to cost-effectively use and improve existing venues rather than create new venues that lack recognition, acceptance and require substantial resourcing. Examples of the existing published venues from APWA, the Rebuild America Coalition and ASCE/CERF are attached to provide a modest indication of the significant venues that can be effectively channeled to inform, promote, coordinate and involve the broad public works constituency.





## IX. Summary

The success of this bold national construction goals initiative for public works infrastructure depends, in the end, upon the ability of the initial implementation "partners" to establish a compelling case for these goals, generate the requisite enthusiasm, commitment and participation from the large public works stakeholder constituency and develop the effective implementation mechanisms that ensure program success. The strategy outlined in this report is an important first step towards success, but, nevertheless, only the first step in a process; moreover it is a draft strategy that will now be more closely evaluated and modified, as appropriate, by the public works stakeholder community in the process of completing the public works sector construction goals implementation plan.

The process has begun with this initial strategy; it will be continued through the monthly (or more often) meetings of the public works oversight group, commencing in July with the first meeting of the four organizations who have stepped forward to provide the initial leadership for this vital national initiative.









